6.3.3.1.2 Homegrown Produce Ingestion—The homegrown produce ingestion exposure route includes an evaluation of COPC concentrations in plants caused by both root uptake and irrigation with contaminated groundwater. At each retained site, the total source concentration evaluated in the homegrown produce ingestion exposure route is calculated by combining the 95% UCL on the mean concentration for a given COPC (or the maximum concentration if the maximum is less than the 95% UCL) with the soil concentration that would result from equilibrium partitioning between soil and groundwater contaminated with the COPC.

Homegrown produce concentrations assumed for each COPC are presented in Table D-13. To evaluate the average soil concentration of radioactive COPCs in soil when irrigating with groundwater, the integrated form of Equation 5.39 in *Nuclear Regulatory Commission (NRC) Guidance Document* (NRC 1993) is used:

$$C_s(t) = \frac{\frac{i_v}{L_i + \lambda}\left(t_e + \frac{e^{-(L_i + \lambda)t_e}}{L_i + \lambda}\right) + \frac{C_{so}}{L_i + \lambda}\left(1 - e^{-(L_i + \lambda)t_e}\right) - \frac{i_v}{(L_i + \lambda)^2}}{t_e} \qquad (6\text{-}5)$$

where

$C_s(t)$ = the average concentration of a COPC in soil for the exposure period, t_e (pCi/g)

i_v = COPC input rate from irrigation (pCi/g-day)

L_i = leach rate constant $(day)^{-1}$

t_e = exposure period [10,950 days (30 years × 365 days/year)]

C_{so} = average concentration of COPC in the top 3 m (10 ft) of soil at the start of the residential exposure period (pCi/g)

λ = $\ln 2 / t_{1/2}$ where $t_{1/2}$ is the half-life of the radionuclide expressed in days

For nonradioactive COPCs, this equation reduces to the following:

$$C_s(t) = \frac{\frac{i_v}{L_i}\left(t_e + \frac{e^{-(L_i t_e)}}{L_i}\right) + \frac{C_{so}}{L_i}\left(1 - e^{-(L_i t_e)}\right) - \frac{i_v}{L_i^2}}{t_e} \qquad (6\text{-}6)$$

The COPC input rate from irrigation is given by the following equation:

$$i_v = C_w \times \frac{IR}{\rho \times T} \qquad (6\text{-}7)$$

where

6-20

$\acute{I}_v$ = COPC input rate from irrigation (mg/g-day or pCi/g-day)

C_W = average concentration of a COPC in groundwater for the exposure period (mg/L or pCi/L)

I_R = irrigation rate (8.47 L/m²-day × 90 days/365 yrs) (Maheras et al. 1994)

ρ = soil density (1.5E+06 g/m³)

T = thickness of root zone (0.2 m) (7 in.) [International Atomic Energy Agency (IAEA) 1994].

The leach rate constant is given by the following equation (Baes and Sharp 1983):

$$L_i = \frac{P}{\theta_c \times \left(1 + \dfrac{K_d \times \rho}{\theta_c}\right) \times T} \times CF \tag{6-8}$$

where

L_i = leach rate constant (day)$^{-1}$

P = net water percolation rate (0.86 m/1 year) [infiltration rate of 0.1 m/1 year, as presented in *INEL Track 2 Guidance* (DOE-ID 1994), plus the contribution from irrigation]

θ_c = volumetric water content in source volume (0.41 m³/m³) (Rood 1994)

K_d = COPC-specific soil-to-water partition coefficient (cm³/g)

ρ = soil density (1.5 g/cm³)

T = thickness of root zone (0.2 m) (IAEA 1994)

CF = conversion factor (1 year/365 days).

Finally. concentrations of COPCs in affected homegrown produce are calculated using the following equation (EPA 1995b):

$$C_p(t) = C_s(t) \times B_v \tag{6-9}$$

where

$C_p(t)$ = average concentration of a COPC in homegrown produce from root uptake (pCi/g or mg/kg)

Cs(t) = average concentration of a COPC in soil for the exposure period (pCi/g or mg/kg)

Bv = COPC-specific soil-to-plant uptake coefficient (mass of COPC/dry mass of plant material per mass of COPC/dry mass of soil).

Homegrown produce contaminant concentrations calculated using the above equations are presented in Table D-13.

6.3.3.1.3   External Radiation Exposure—For the external radiation exposure route, standard EPA protocols are used to estimate risks for all retained sites. In other words, external radiation exposure risks are calculated by multiplying radiation intakes for specific isotopes by the radionuclide slope factors presented in EPA's Health Effects Assessment Summary Tables (HEAST) (EPA 1995a). The standard EPA protocols are used because all of the retained sites in the BRA have radionuclide contamination that is at least 0.2 m (6 in.) thick over a large area. This thickness is large enough to satisfy the assumption that an increase in source thickness will not cause an increase in surface radiation exposures.

6.3.3.1.4   Dermal Exposure—Similarly to the soil ingestion exposure route, dermal exposure to soil is not likely to occur from more than one release site at a time. Therefore, dermal exposure to soil is evaluated on a site-by-site basis.

Potential risks from dermal absorption from soil are based on the potential for a chemical to be absorbed through skin. This potential is quantified by chemical-specific absorption factors (ABS) (i.e., the fraction of a chemical that may be absorbed through skin).

ABS values are not well quantified for many of the chemicals that have been detected at WAG 4. In the absence of this chemical-specific information, EPA Region III has issued general guidelines for evaluating dermal exposure. These guidelines include recommendations on default ABS values in the absence of chemical-specific values (EPA 1995c). Based on EPA (1995c), organic chemicals generally have relatively high ABS values and therefore have the greatest potential for being absorbed through the skin. To evaluate potential dermal exposures from contact with volatile organic chemicals (VOCs), EPA (1995c) recommends assuming an ABS value of three percent, or 0.03, for VOCs with vapor pressures (VP) lower than the VP of benzene (95.2 mm Hg). For VOCs with a VP greater than 95.2 mm Hg, an ABS of 0.05 percent, or 0.0005, should be assumed. For semi-volatile organic chemicals (VOCs), EPA (1995c) recommends use of an ABS of 10 percent, or 0.10.

Dermal uptake is generally not an important route of uptake for metals or radionuclides, which have small dermal absorption and dermal permeability constants; therefore, this BRA does not include an evaluation of potential risks from dermal absorption of metals and radionuclides in soil and groundwater. An exception to this rule is the evaluation of potential risks from dermal exposure to arsenic in soil and groundwater. Arsenic is retained as a soil COPC at CFA-04. The ABS recommended for arsenic is three percent, or 0.03 (EPA 1995). This ABS value is relatively high; therefore, arsenic is included with organics in the evaluation of potential risks from dermal contact with soil at CFA-04.

Modeling of arsenic to future residential receptor well locations (see Section 6.3.3.3, Groundwater Exposure Pathway) is also conducted to because arsenic is retained as a soil COPC at CFA-04. If results of the groundwater modeling indicate that arsenic is expected to reach future residential receptor well locations, then arsenic will also be included in the groundwater cumulative risk analysis, and potential risks posed by dermal contact with arsenic in groundwater will be evaluated.

6.3.3.1.5 Soil Exposure Pathway Assumptions—The evaluation of potential exposures from soil pathways is based on the following assumptions:

- Soil pathway exposures from multiple release sites are insignificant (see Section 6, Uncertainty Analysis).

- The likelihood that a future resident will raise meat and dairy products on a residential lot at WAG 4 is assumed to be negligible, in accordance with INEEL guidance on analysis of the homegrown produce ingestion exposure route (LMITCO 1996). As a result, risks from the ingestion of meat and dairy products are not quantitatively evaluated in the BRA.

- A receptor is assumed to be present at each retained site for the full exposure duration (30 years for a residential receptor and 25 years for an occupational receptor).

6.3.3.2 Air Exposure Pathway Methodology. The following air exposure pathways are identified in the CSM (Figures 6-1 through 6-3) as potentially complete for the residential and/or occupational exposure scenarios:

- Inhalation of fugitive dust

- Inhalation of volatiles.

Because there is a possibility that contamination from multiple sites can mix together within the air volume above WAG 4, the air pathway is analyzed in a cumulative manner in the WAG 4 BRA. To perform this cumulative analysis, a WAG-wide average soil concentration is calculated for each COPC. The concentration of each COPC in the respirable particulate matter above WAG 4 is assumed to equal this average soil concentration. Averaging contaminant concentrations above WAG 4 for the air pathway produces one contaminant-specific risk estimate for each air pathway exposure route [i.e., for each time period, each air pathway exposure route has the same risk or HI at every retained site (see Section 6.5)].

The equations discussed below will be used to estimate airborne contaminant concentrations:

$$C_{air} = CF \times R \times C_{soil} \tag{6-10}$$

where

C_{air} = contaminant concentration in air (mg/m^3 or pCi/m^3)

CF = conversion from kg to mg for nonradionuclides or g to mg for radionuclides

R = airborne respirable particulate matter concentration (0.011 mg/m^3). This value is given in Appendix B of the *INEL Site Environmental Monitoring Reports* (e.g., Hoff et al. 1993), and represents the arithmetic mean, of weekly airborne respirable particulate matter concentrations by the TAN low volume air sampling station

C_{soil} = WAG average contaminant soil concentration (mg/kg or pCi/g) weighted by site area.

and

$$C_{soil} = \frac{\Sigma \ C_n \ A_n}{A_T}$$

(6-11)

where

C_n = contaminant soil concentration at site n (mg/kg or pCi/g)

A_n = surface area of site n (m^2)

A_T = total area of the WAG 4 retained sites (m^2) for which non-volatile contaminants are present in the top 0.15 m (0.5 ft) and 3.05 m (10 ft), respectively, for the occupational and residential exposure scenarios

n = number of retained sites.

The equation used for estimating concentrations of airborne volatiles is as follows:

$$C_{air} = \frac{\Sigma \ (C_n \ / \ VF_n) \ A_n}{A_T}$$

(6-12)

where

C_n = contaminant soil concentration at site n (mg/kg)

VF_n = volatilization factor [as described in *INEL Track 2 Guidance* (DOE-ID 1994)] for site n (m^3/kg)

A_n = surface area of site n (m^2)

A_T = total area of the WAG 4 retained sites (m^3) for which volatile contaminants are present in the top 0.15 m (0.5 ft) and 3.05 m (10 ft), respectively, for the occupational and residential exposure scenarios

These equations produce conservatively high estimates of airborne COPC concentrations because no credit is taken for dilution of airborne concentrations caused by dust blown from uncontaminated areas of the WAG.

As with the soil pathway analysis, the air pathway receptor is either a current occupational worker (who is assumed to be exposed for 25 years) or a hypothetical future resident (who is exposed for 30 years). Air pathway risks and HQs are calculated at 0 and 100 years in the future for the occupational scenario, and at 100 years in the future for the residential scenario. Estimated concentrations of COPCs in fugitive dust and estimated concentrations of volatiles for each exposure period are presented in Tables D-15 through D-17.

6.3.3.2.1 *Air Exposure Pathway Assumptions*—The evaluation of potential exposures from air pathways is based on the following assumptions:

- The concentration of each retained contaminant in the respirable particulate matter above the WAG will be equal to each contaminant's WAG wide average soil concentration.

- The airborne concentration of each retained contaminant will be the same at every point inside the WAG boundaries.

- The air pathway receptor will be assumed to spend the entire exposure duration (25 years for current occupational workers and 30 years for future residents) working or living within the boundaries of the WAG.

6.3.3.3 Groundwater Exposure Pathway. To quantify potential risks from exposure via groundwater pathways, modeling of contaminant concentrations in groundwater is required. For the groundwater pathway analysis, every contaminant that is not eliminated by the contaminant screening process (described in Section 6.2) is assumed to have the potential for migrating to groundwater, but only manmade sources of contamination are considered in the analysis. The following groundwater exposure pathways are identified in the CSM (Figures 6-1 through 6-3) as potentially complete for the future residential exposure scenario:

- Ingestion of groundwater

- Dermal absorption of groundwater

- Inhalation of volatiles produced by indoor use of groundwater.

WAG 4 includes surface or buried sources of potential groundwater contamination. Precipitation, infiltrating the subsurface and passing through these surface and near surface contaminated soils, can leach contamination to the aquifer beneath WAG 4.

Groundwater concentrations resulting from surface and near surface sources are estimated using the computer code GWSCREEN (Rood 1994). For each COPC, GWSCREEN produces groundwater concentrations versus time as the code output. From this output, the maximum 30-year average groundwater concentration of each COPC, and the 30-year average concentrations at 100 years in the future, are calculated. The average concentrations at year 100 are used to calculate groundwater pathway risks for the residential exposure scenario, and the maximum average concentrations are used to calculate maximum expected groundwater risks.

The total mass of each contaminant considered in the GWSCREEN modeling is calculated by summing the contaminant masses from the retained sites. The contaminant mass at each retained site is derived by multiplying the representative average soil concentration for each contaminant (or maximum detected soil concentration if paucity of data precludes preparation of a volume- and depth-weighted average concentration) by the mass of contaminated soil at the site. For example, if a contaminant has a volume- and depth-weighted average concentration of 7 mg/kg at a site with dimensions of $10 \times 10 \times 1$ m ($30 \times 30 \times 3$ ft), the mass of the contaminant that would be used in the GWSCREEN modeling would be 1.05E+6 mg (i.e., [7mg/kg] × [10m × 10m × 1m] × [1.5 g/cm3] × [1E+06 cm3/m3] × [1E-03 kg/g] = 1.05E+6 mg).

Data used in this groundwater analysis are contained in Table 6-5 through Table 6-11. GWSCREEN input parameters are shown in Table 6-6 through Table 6-8. The COPC masses used in the GWSCREEN modeling are shown in Table 6-9 while resulting groundwater concentrations are presented in Table 6-10 and 6-11.

Table 6-5. Interbed thickness for wells in the vicinity of CFA.

Well	Cumulative Vadose Zone Interbed Thickness (m)	Well	Cumulative Vadose Zone Interbed Thickness (m)
CFA-2	12.8	LF2-09	33.5
LF3-09	16.5	LF3-11	34.6
LF2-12	17.7	LF2-08	36.4
LF2-10	23.2	LF2-11	39.5
LF3-11A	23.2	LF3-10	41.5
LF3-08	30.8	CFA-1	52.1

Table 6-6. GWSCREEN parameters and the values used for transport modeling.

Variable	Parameter Description	Value[a]	Units
L	Source length parallel to aquifer flow direction	site-specific	M
W	Source width perpendicular to aquifer flow direction	site-specific	M
D_s	Thickness of source	site-specific	M
I	Infiltration rate (Darcy flux)	0.1	m/yr
v_a	Aquifer pore velocity	570	m/yr
θ_s	Volumetric water content in source	0.3	Unitless
θ_u	Volumetric water content in unsaturated zone	0.3	Unitless
ρ_s	Bulk density at source	1.5	g/cm^3
ρ_u	Bulk density in unsaturated zone	1.5	g/cm^3
ρ_a	Bulk density of aquifer	1.9	g/cm^3
K_{ds}	Sorption coefficient in source	contaminant-specific	mL/g
K_{du}	Sorption coefficient in unsaturated zone	contaminant-specific	mL/g
K_{da}	Sorption coefficient in aquifer	contaminant-specific	mL/g
η	Porosity of aquifer	0.1	Unitless
T	Depth to aquifer below contamination zone	site-specific	M
α_L	Dispersivity in the direction of aquifer flow	9	M
α_T	Dispersivity perpendicular to direction of flow	4	M
Q_I	Initial contaminant mass or activity	site- and contaminant-specific	mg or Ci
$t_{1/2}$	Half-life of contaminant	contaminant-specific	Y
EWST	Equivalent well screen thickness	15	M
X	Distance from source to receptor, parallel to flow	site-specific	M
Y	Distance from source to receptor, perpendicular to flow	site-specific	M

a. Values are default Track 2 numbers unless otherwise noted.

Source length and width derivation is described in text.

The thickness of the source volume is based on predicted leached depth, as described in text.

Sorption coefficients are, in this analysis, identical for source, unsaturated, and saturated zones.

Depth to aquifer is the cumulative vadose zone interbed thickness for each site.

Distance from source to receptor is unique for each source/receptor, based on location of ten receptors at downgradient edge of this system.

Table 6-7. Modeling details for each site.

Site	UTM[a] (East, m)	UTM (North, m)	Offset[b] parallel to flow (m)	Offset perpendicular to flow (m)	CVZIT[c] (m)	Length (parallel to flow) (m)	Width (perpendicular to flow) (m)	Thickness of source (m)	Area (m²)	Volume (m³)	Contaminated Soil Mass (kg)
CFA-13	342910.0	4821062.0	-577.3	174.9	14.0	5.0	5.0	9.1	25.0	227.5	3.41E+05
CFA-15	342759.7	4820694.4	-209.7	24.5	13.5	0.5	0.5	7.9	0.3	2.3	3.46E+03
CFA-04	342735.2	4820484.7	0.0	0.0	14.0	150.7	45.6	5.5	6875.3	37813.2	5.67E+07
CFA-17a	343402.6	4828685.0	-8200.2	667.4	18.5	48.6	33.5	3.8	1629.9	6217.1	9.33E+06
CFA-17b	343390.0	4828718.5	-8233.7	654.9	18.5	18.3	18.1	3.8	331.1	1262.9	1.89E+06
CFA-47	343443.6	4828685.0	-8200.2	708.4	18.5	1.0	1.0	3.8	0.9	3.5	5.27E+03
CFA-07a	343547.3	4821934.0	-1449.2	812.1	46.3	2.7	2.7	3.5	7.3	25.5	3.83E+04
CFA-07b	343550.0	4821936.7	-1451.9	814.8	46.3	2.7	2.7	3.5	7.3	25.5	3.83E+04
CFA-12	342728.6	4821453.5	-968.7	-6.5	12.9	3.7	3.7	2.6	13.4	34.8	5.22E+04
CFA-08	343737.4	4821772.8	-1288.0	1002.2	47.0	305.0	61.0	9.9	18605.0	184189.5	2.76E+08
CFA-08b	344019.3	4822252.9	-1768.1	1284.1	49.0	62.4	89.2	7.6	5566.1	42302.2	6.35E+07
CFA-10	343182.5	4820914.5	-429.8	447.4	19.0	40.7	19.9	3.0	808.1	2463.1	3.69E+06
CFA-26	342821.6	4820851.5	-366.7	86.4	13.0	30.5	30.5	5.0	930.3	4651.3	6.98E+06
CFA-42	343695.9	4821661.0	-1176.2	960.7	40.9	9.1	9.1	0.2	83.6	12.7	1.91E+04
CFA-05	343660.0	4820999.0	-514.3	924.9	32.0	69.5	69.5	5.8	4829.2	27965.7	4.19E+07
CFA-05b	343590.7	4821014.8	-530.1	855.5	31.5	69.5	37.8	5.8	2626.4	15209.4	2.28E+07
CFA-52	342945.6	4821205.3	-720.5	210.5	13.5	3.5	2.4	2.9	8.4	24.4	3.65E+04
CFA-1709	342962.7	4821246.6	-761.8	227.5	13.8	2.3	2.1	2.6	4.9	12.8	n/a[d]
CFA-2	343401.4	4828673.7	-8189.0	666.2	16.5	4.1	2.4	6.6	9.9	65.1	n/a
CFA-610	342945.3	4821255.3	-770.5	210.1	13.0	3.5	2.4	2.9	8.6	25.0	n/a
CFA-658	343251.3	4821242.8	-758.0	516.1	24.0	6.3	3.7	1.7	23.0	38.5	n/a
CFA-713-4	343043.9	4821050.1	-565.3	308.7	12.3	23.2	9.1	0.8	212.4	161.8	n/a
CFA-713-5	343047.6	4821054.8	-570.1	312.4	12.3	18.6	9.1	0.8	169.7	129.3	n/a

Table 6-7. (continued).

Site	UTM[a] (East, m)	UTM (North, m)	Offset[b] parallel to flow (m)	Offset perpendicular to flow (m)	CVZIT[c] (m)	Length (parallel to flow) (m)	Width (perpendicular to flow) (m)	Thickness of source (m)	Area (m²)	Volume (m³)	Contaminated Soil Mass (kg)
CFA-723	342988.1	4820973.1	-488.4	253.0	12.0	5.7	3.0	2.9	17.3	50.0	n/a
CFA-726	343109.0	4821080.0	-595.2	373.9	16.0	3.9	2.7	2.0	10.6	21.0	n/a
CFA-728	343126.9	4821130.0	-645.2	391.8	17.3	3.9	2.7	2.3	10.6	24.3	n/a
CFA-729	342973.5	4821251.1	-766.4	238.3	13.0	6.5	3.0	2.3	19.7	45.0	n/a
CFA-733	342988.1	4820973.1	-488.4	253.0	12.0	5.7	3.0	2.9	17.3	50.0	n/a
CFA-734	343002.9	4821284.7	-800.0	267.8	16.0	4.1	2.4	2.3	9.9	22.6	n/a
CFA-735	342909.2	4821326.3	-841.6	174.0	14.5	3.8	2.4	2.6	9.2	23.9	n/a
CFA-741-7	342988.1	4820973.1	-488.4	253.0	10.8	23.2	9.1	0.8	212.4	161.8	n/a
CFA-745	342950.3	4821123.8	-639.0	215.1	11.0	4.2	2.7	1.7	11.5	19.3	n/a
CFA-746	342878.1	4821146.6	-661.9	142.9	10.8	2.3	2.1	3.2	4.9	15.6	n/a
CFA-747	343290.2	4821837.0	-1352.3	555.0	47.0	4.6	2.7	4.7	12.5	59.3	n/a
CFA-748-B	342961.8	4821135.0	-650.3	226.6	11.0	4.2	2.7	1.7	11.5	19.3	n/a
CFA-750	342988.1	4820973.1	-488.4	253.0	12.0	5.7	3.0	2.9	17.3	50.0	n/a
CFA-46	342836.5	4821119.3	-634.6	101.4	12.00	5.8	5.8	6.9	33.2	228.9	n/a

a. UTM = Universal Transverse Meridian north and east coordinates in meters.

b. Offset = distance in meters of the center of each site from the center of the reference site (CFA-04) parallel and perpendicular to the groundwater flow direction. A negative value parallel to groundwater flow direction indicates the site is located upgradient of CFA-04. Positive values perpendicular to groundwater flow are sites to the east of CFA-04.

c. CVZIT = cumulative vadose zone interbed thickness

d. n/a = tanks identified in the Facility Analysis of the OU 4-13 Work Plan were modeled assuming one-tank volume of product released (see Table 6-8). Contaminant inventories for these are based not on mass of contaminated soil but on mass contained in one tank volume. Tanks at sites CFA-26 and CFA-52 have petroleum inventory estimates based on this concept but also have sampling results which are used with estimates of contaminated soil mass to calculate contaminant inventories.

Table 6-8. Parameter values for contents of modeled tanks.

Tank	Modeled Contents	Kd (mL/g)	Tank Volume (L)	Total Modeled TPH Mass (mg)
CFA-713-4	TPH-gasoline	1.4	37850	2.65E+10
CFA-713-5	TPH-gasoline	1.4	30280	2.12E+10
CFA-745	TPH-gasoline	1.4	1892.5	1.32E+09
CFA-46	TPH-diesel	1.78	18927	1.61E+10
CFA-1709	TPH-diesel	1.78	946.25	8.04E+08
CFA-2	TPH-diesel	1.78	3785	3.22E+09
CFA-52	TPH-diesel	1.78	1892.5	1.61E+09
CFA-658	TPH-diesel	1.78	3785	3.22E+09
CFA-729	TPH-diesel	1.78	3785	3.22E+09
CFA-741-7	TPH-diesel	1.78	37850	3.22E+10
CFA-746	TPH-diesel	1.78	1078.725	9.17E+08
CFA-748-B	TPH-diesel	1.78	3785	3.22E+09
CFA-750	TPH-diesel	1.78	3785	3.22E+09
CFA-26	TPH-heating oil	1.98	209700	2.08E+11
CFA-610	TPH-heating oil	1.98	1892.5	1.87E+09
CFA-723	TPH-heating oil	1.98	3785	3.75E+09
CFA-726	TPH-heating oil	1.98	1892.5	1.87E+09
CFA-728	TPH-heating oil	1.98	3785	2.06E+10
CFA-733	TPH-heating oil	1.98	20817.5	3.75E+09
CFA-734	TPH-heating oil	1.98	1892.5	1.87E+09
CFA-735	TPH-heating oil	1.98	1892.5	1.87E+09
CFA-747	TPH-heating oil	1.98	3785	3.75E+09

TPH = total petroleum hydrocarbons

Table 6-9. COPC total masses or activities in soil (sources to groundwater)

Contaminant	Modeled Decay Product[a]	Half-life (yr)	Sorption Coefficient, Kd (mL/g)[b]	Total Inventory in Soil to be Transported to Groundwater (mg or Ci)
Ac-228		7.00E-04	0.00E+00	7.84E-02
	Th-228			2.87E-05
Ag-108m		1.27E+02	9.00E+01	4.80E-05
Am-241		4.32E+02	3.40E+02	3.38E-02
	Np-237			6.96E-06
Ba-133		1.05E+01	5.00E+01	4.73E-06
Bi-212		1.15E-04	1.00E+02	7.64E-02
	Pb-208[c]			4.38E-24
Bi-214		3.80E-05	1.00E+02	6.32E-02
	Pb-210			1.14E-07
Cs-137		3.02E+01	5.00E+02	7.63E+00
Eu-152		1.36E+01	0.00E+00	6.53E-05
Pb-212		1.21E-03	1.00E+02	8.03E-02
	Pb-208			4.85E-23
Pu-238		8.78E+01	2.20E+01	7.12E-04
	U-234			2.55E-07
Pu-239/240		2.41E+04	2.20E+01	1.44E-02
Ra-226		1.60E+03	1.00E+02	2.95E-01
Tl-208		5.80E-06	0.00E+00	7.32E-02
	Pb-208			2.12E-25
U-234		2.45E+05	6.00E+00	1.17E-01
U-235		7.04E+08	6.00E+00	5.93E-02
U-238		4.47E+09	6.00E+00	1.30E-01
Arsenic		n/a[d]	3.00E+00	7.49E+08
Benzo(a)anthracene		n/a	1.19E+03	3.58E+05
Benzo(b)fluoranthene		n/a	3.69E+03	1.67E+05
Benzo(g,h,i)perylene		n/a	4.74E+03	2.98E+05
Chlorodifluoromethane		n/a	1.73E-01	6.98E+05
Di-n-butylphthalate		n/a	1.02E+02	3.42E+06
Lead		n/a	1.00E+02	5.12E+09

Table 6-9. (continued).

Contaminant	Modeled Decay Product[a]	Half-life (yr)	Sorption Coefficient, Kd (mL/g)[b]	Total Inventory in Soil to be Transported to Groundwater (mg or Ci)
Mercury	n/a	1.00E+02	5.53E+09	
Phenanthrene	n/a	4.23E+01	8.11E+04	
Phenol	n/a	8.64E-02	2.16E+05	
Tetrachloroethene	n/a	7.89E-01	9.50E+02	
1,1,1-Trichloroethane	n/a	3.27E-01	2.92E+02	
TPH-diesel	n/a	1.78E+00	6.77E+10	
TPH-gasoline	n/a	1.40E+00	4.90E+10	
TPH-heating oil	n/a	1.78E+00	2.47E+11	

a. Some parent radionuclides (Ac-228, Am-241, Bi-214, and Pu-238), have relatively short half-lives and high sorption coefficients. For these radionuclides the first daughter product (Th-228, Np-237, Pb-210, and U-234, respectively) was modeled.

Daughter product inventories were obtained from the relationship of activity and half-life:

$$(Activity)_{daughter} = (Activity)_{parent}*[(half-life)_{parent}/(half-life)_{daughter}]$$

b. For radionuclide contaminants with extremely short half-lives (i.e., less than 1.0 yr), the COCs were assumed to decay entirely to stable products before exiting the system. These contaminants were converted from parent curies to stable product milligrams (Pb-208 for thorium series decay chain COCs and Mo-95 for Zr-95). The Pb-208 totals were added to the stable lead inventory for these sites before modeling. Mo-95 inventory was deemed insignificant for the groundwater pathway.

c. Pb-208 is a stable form of elemental lead. The short-lived parent curies were converted to milligrams of Pb-208, which was added to the total lead inventory.

d. Half-life refers to radiological decay. Here, non-radiological COCs are considered to be free of any decay-type loss mechanisms. Half-life values were taken from the EPA Health Effects Assessment Summary Tables.

n/a Not applicable

Table 6-10. Groundwater concentrations for WAG 4.

Contaminant	Modeled Decay Product[a]	100-130 Year Concentration[b] (mg/L or pCi/L)
Ac-228 (Th-228)[c]		0.00E+00
Ag-108m		0.00E+00
Am-241 (Np-237)[c]		0.00E+00
	U-233	0.00E+00
	Th-229	0.00E+00
Ba-133		0.00E+00
Bi-212 (Pb-208)[d]		n/a[d]
Bi-214 (Pb-210)[c]		0.00E+00
Cs-137		0.00E+00
Eu-152		4.79E-03
Pb-212 (Pb-208)[d]		n/a
Pu-238 (U-234)[c]		0.00E+00
	Th-230	0.00E+00
	Ra-226	0.00E+00
	Pb-210	0.00E+00
Pu-239/240		0.00E+00
	U-235	0.00E+00
	Pa-231	0.00E+00
	Ac-227	0.00E+00
Ra-226		0.00E+00
	Pb-210	0.00E+00
Tl-208 (Pb-208)[d]		n/a
U-234		0.00E+00
	Th-230	0.00E+00
	Ra-226	0.00E+00
	Pb-210	0.00E+00
U-235		0.00E+00
	Pa-231	0.00E+00
	Ac-227	0.00E+00
U-238		0.00E+00
	U-234	0.00E+00

Table 6-10. (continued).

Contaminant	Modeled Decay Product[a]	100-130 Year Concentration[b] (mg/L or pCi/L)
	Th-230	0.00E+00
	Ra-226	0.00E+00
	Pb-210	0.00E+00
Zr-95 (Mo-95)[e]		n/a[e]
1,1,1-Trichloroethane		0.00E+00
Arsenic		0.00E+00
Benzo(a)anthracene		0.00E+00
Benzo(b)fluoranthene		0.00E+00
Benzo(g,h,i)perylene		0.00E+00
Chlorodifluoromethane		1.74E-04
Di-n-butylphthalate		0.00E+00
Lead		0.00E+00
Mercury		0.00E+00
Phenanthrene		0.00E+00
Phenol		7.10E-05
Tetrachloroethene		0.00E+00
TPH-diesel[f]		0.00E+00
TPH-gasoline		0.00E+00
TPH-heating		0.00E+00

a. Some radionuclide COCs decay to significant daughter products; the daughter product ingrowth is included here.

b. The groundwater concentrations reported in this table represent the maximum predicted in a network of ten receptor aquifer wells located in a line perpendicular to the flow direction immediately downgradient of the reference site (CFA-04).

c. Radionuclide contaminants that have short half-life relative to the vadose zone transit time were modeled as their first radioactive decay product.

These include Ac-228, Am-241, Bi-214, and Pu-238 which were modeled as Th-228, Np-237, Pb-210, and U-234, respectively.

d. Some radionuclides with very short half-life (<1.0 yr) that have no significant radioactive decay products were modeled as stable decay products. Bi-212, Pb-212, Tl-208 soil inventories were converted to stable lead which was added to the total lead inventory.

e. Zr-95 is also very short-lived with no significant radioactive decay products; the inventory of Zr-95 was converted to stable Mo-95, which was found to be an insignificant soil inventory relative to the molybdenum MCL.

f. TPH = total petroleum hydrocarbon